LM118/LM218/LM318 Operational Amplifiers

General Description

The LM118 series are precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate. They feature a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

The LM118 series has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/µs and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 µs.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

The LM218 is identical to the LM118 except that the LM218 has its performance specified over a −25˚C to +85˚C temperature range. The LM318 is specified from 0˚C to +70˚C.

Features

- 15 MHz small signal bandwidth
- Guaranteed 50V/µs slew rate
- Maximum bias current of 250 nA
- Operates from supplies of ±5V to ±20V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

Fast Voltage Follower

(Note 1)

![Fast Voltage Follower Diagram](Note 1)

Note 1: Do not hard-wire as voltage follower (R1 ≥ 5 kΩ)
Absolute Maximum Ratings (Note 7)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ±20V
Power Dissipation (Note 2) 500 mW
Differential Input Current (Note 3) ±10 mA
Input Voltage (Note 4) ±15V
Output Short-Circuit Duration Continuous
Operating Temperature Range
- LM118 −55˚C to +125˚C
- LM218 −25˚C to +85˚C
- LM318 0˚C to +70˚C
Storage Temperature Range −65˚C to +150˚C

Lead Temperature (Soldering, 10 sec.)
- Hermetic Package 300˚C
- Plastic Package 260˚C
- Soldering Information
  - Dual-In-Line Package Soldering (10 sec.) 260˚C
  - Small Outline Package Vapor Phase (60 sec.) 215˚C
  - Infrared (15 sec.) 220˚C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

ESD Tolerance (Note 8) 2000V

Electrical Characteristics (Note 5)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM118/LM218</th>
<th>LM318</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>$T_A = 25˚C$</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>$T_A = 25˚C$</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>$T_A = 25˚C$</td>
<td>120</td>
<td>250</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>$T_A = 25˚C$</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Supply Current</td>
<td>$T_A = 25˚C$</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>$T_A = 25˚C$, $V_S = ±15V$</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>$T_A = 25˚C$, $V_S = ±15V$, $A_V = 1$ (Note 6)</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Small Signal Bandwidth</td>
<td>$T_A = 25˚C$, $V_S = ±15V$</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>$T_A = 25˚C$</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>$T_A = 25˚C$</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>$T_A = 25˚C$</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>$T_A = 125˚C$</td>
<td>4.5</td>
<td>7</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>$V_S = ±15V$, $V_{OUT} = ±10V$</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>$V_S = ±15V$, $R_L = 2$kΩ</td>
<td>±12</td>
<td>±13</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>$V_S = ±15V$</td>
<td>±11.5</td>
<td>±11.5</td>
</tr>
<tr>
<td>Common-Mode Rejection Ratio</td>
<td>$V_S = ±15V$</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Supply Voltage Rejection Ratio</td>
<td>$V_S = ±15V$</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

Note 2: The maximum junction temperature of the LM118 is 150˚C, the LM218 is 110˚C, and the LM318 is 110˚C. For operating at elevated temperatures, devices in the H08 package must be derated based on a thermal resistance of 160˚C/W, junction to ambient, or 20˚C/W, junction to case. The thermal resistance of the dual-in-line package is 100˚C/W, junction to ambient.

Note 3: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 4: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 5: These specifications apply for $±5V \leq V_S \leq ±20V$ and $−55˚C \leq T_A \leq +125˚C$ (LM118), $−25˚C \leq T_A \leq +85˚C$ (LM218), and $0˚C \leq T_A \leq +70˚C$ (LM318). Also, power supplies must be bypassed with 0.1 µF disc capacitors.

Note 6: Slew rate is tested with $V_S = ±15V$. The LM118 is in a unity-gain non-inverting configuration. $V_{IN}$ is stepped from $−7.5V$ to $+7.5V$ and vice versa. The slew rates between $−5.0V$ and $+5.0V$ and vice versa are tested and guaranteed to exceed 50V/µs.

Note 7: Refer to RETS118X for LM118H and LM118J military specifications.

Note 8: Human body model, 1.5 kΩ in series with 100 pF.
Typical Performance Characteristics

LM118, LM218

Input Current

Voltage Gain

Power Supply Rejection

Input Noise Voltage

Common Mode Rejection

Supply Current
Typical Performance Characteristics LM118, LM218 (Continued)

Large Signal Frequency Response

Open Loop Frequency Response

Voltage Follower Pulse Response

Inverter Pulse Response

Open Loop Frequency Response

Large Signal Frequency Response
Typical Performance Characteristics
LM318

Input Current

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Input Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
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<tr>
<td>20</td>
<td>30</td>
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<td>40</td>
<td>50</td>
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<tr>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>70</td>
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</tbody>
</table>

Input Voltage Gain

<table>
<thead>
<tr>
<th>Supply Voltage (µV)</th>
<th>Voltage Gain (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>95</td>
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<tr>
<td>10</td>
<td>100</td>
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<tr>
<td>15</td>
<td>105</td>
</tr>
<tr>
<td>20</td>
<td>110</td>
</tr>
</tbody>
</table>

Power Supply Rejection

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Supply Rejection (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1k</td>
<td>20</td>
</tr>
<tr>
<td>10k</td>
<td>40</td>
</tr>
<tr>
<td>100k</td>
<td>60</td>
</tr>
<tr>
<td>1M</td>
<td>80</td>
</tr>
<tr>
<td>10M</td>
<td>100</td>
</tr>
</tbody>
</table>

Input Noise Voltage

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Noise (µV/√Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>1k</td>
<td>100</td>
</tr>
<tr>
<td>10k</td>
<td>300</td>
</tr>
<tr>
<td>100k</td>
<td>1000</td>
</tr>
</tbody>
</table>

Common Mode Rejection

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Common Mode Rejection (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>1k</td>
<td>40</td>
</tr>
<tr>
<td>10k</td>
<td>60</td>
</tr>
<tr>
<td>100k</td>
<td>80</td>
</tr>
<tr>
<td>1M</td>
<td>100</td>
</tr>
</tbody>
</table>

Supply Current

<table>
<thead>
<tr>
<th>Supply Voltage (µV)</th>
<th>Supply Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4.0</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
</tr>
<tr>
<td>15</td>
<td>5.0</td>
</tr>
<tr>
<td>20</td>
<td>5.5</td>
</tr>
</tbody>
</table>

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Typical Performance Characteristics  LM318 (Continued)

Closed Loop Output Impedance

Current Limiting

Input Current

Unity Gain Bandwidth

Voltage Follower Slew Rate

Inverter Settling Time
Typical Performance Characteristics

**LM318** (Continued)

**Large Signal Frequency Response**

![Graph](image1)

- $T_a = 25^\circ C$
- $V_s = \pm 15V$

**Open Loop Frequency Response**

![Graph](image2)

- $T_a = 25^\circ C$
- $V_s = \pm 15V$

**Voltage Follower Pulse Response**

![Graph](image3)

- $V_s = \pm 15V$
- $T_a = 25^\circ C$

**Inverter Pulse Response**

![Graph](image4)

- $T_a = 25^\circ C$
- $V_s = \pm 15V$
**Auxiliary Circuits**

**Feedforward Compensation for Greater Inverting Slew Rate**  
(Note 9)

*Balance circuit necessary for increased slew.*

**Compensation for Minimum Settling Time**  
(Note 10)

**Isolating Large Capacitive Loads**

**Offset Balancing**

**Overcompensation**

*Note 9: Slew rate typically 150V/µs.*

*Note 10: Slew and settling time to 0.1% for a 10V step change is 800 ns.*
Typical Applications

Fast Voltage Follower
(Note 11)

\[ \text{CF} = \text{Large} \] (\( \text{CF} \geq 50 \text{ pF} \))

*Do not hard-wire as integrator or slow inverter; insert a 10k-5 pF network in series with the input, to prevent oscillation.

Note 11: Do not hard-wire as voltage follower (R1 \( \geq 5 \text{ kΩ} \))

Integrator or Slow Inverter

Differential Amplifier
Typical Applications (Continued)

Fast Sample and Hold

D/A Converter Using Ladder Network

*Optional — Reduces settling time.
Typical Applications (Continued)

Four Quadrant Multiplier

ΔOutput zero.

**"Y" zero

+"X" zero

‡Full scale adjust.

D/A Converter Using Binary Weighted Network

*Optional — Reduces settling time.
Typical Applications (Continued)

Fast Summing Amplifier with Low Input Current

Wein Bridge Sine Wave Oscillator

Instrumentation Amplifier

*Gain ≥ \( \frac{200K}{R_g} \) for \( 1.5K \leq R_g \leq 200K \)
**Connection Diagram**

**Dual-In-Line Package**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>Input</td>
</tr>
<tr>
<td>4</td>
<td>Input</td>
</tr>
<tr>
<td>5</td>
<td>Output</td>
</tr>
<tr>
<td>6</td>
<td>Output</td>
</tr>
<tr>
<td>7</td>
<td>Balance/Compensation 1</td>
</tr>
<tr>
<td>8</td>
<td>Balance/Compensation 2</td>
</tr>
</tbody>
</table>

Top View
Order Number LM118J/883 (Note 13)
See NS Package Number J14A

**Metal Can Package**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>Input</td>
</tr>
<tr>
<td>4</td>
<td>Input</td>
</tr>
<tr>
<td>5</td>
<td>Output</td>
</tr>
<tr>
<td>6</td>
<td>Output</td>
</tr>
<tr>
<td>7</td>
<td>Balance/Compensation 1</td>
</tr>
<tr>
<td>8</td>
<td>Balance/Compensation 2</td>
</tr>
</tbody>
</table>

Top View
Order Number LM118H, LM118H/883 (Note 13),
LM218H or LM318H
See NS Package Number H08C

**Note 12:** Pin connections shown on schematic diagram and typical applications are for TO-5 package.

**Note 13:** Available per JM38510/10107.
Physical Dimensions  inches (millimeters)  unless otherwise noted

Metal Can Package (H)
Order Number LM118H, LM118H/883, LM218H or LM318H
NS Package Number H08C

Ceramic Dual-In-Line Package (J)
Order Number LM118J-8/883
NS Package Number J08A
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

Ceramic Dual-In-Line Package (J)
Order Number LM118J/883
NS Package Number J14A

S.O. Package (M)
Order Number LM318M or LM318MX
NS Package Number M08A
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